Biophysical and molecular determinants of vulnerability to cavitation in young poplars

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PitBulles

Water stress-induced embolism vulnerability in poplar

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Introduction

Trees have to adapt to environmental constraints (heat, water, light,…). Transpiration is a driving force conducting water transport from roots to leaves through xylem conduits. Within these conduits, water is transported under tension which increases whenever the environmental conditions become unfavourable such as water stress. This tension leads to vessels embolism and may be lethal to tree survival if too many vessels become non-functionnal. Vulnerability to embolism depends on tree species and their growth conditions. Literature reports correlation between vulnerability to embolism and tree species sensitivity to water stress. Poplar trees were studied for characterizing their ability to acclimatize to a prolonged moderate water stress.

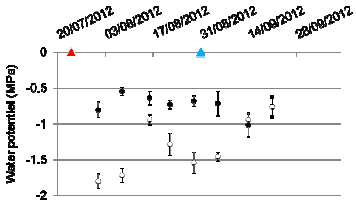
Materials & Methods

Poplar trees (*Populus tremula* x *P. alba*, clone INRA 717-1B4)
4 to 6 month-old trees, grown in greenhouse
Water stress for 5 weeks : soil moisture in pot was maintained to 40 % field capacity
Measured variables of :
Height and diameter ; stomatal conductance and transpiration (porometer); xylem water potential (Schölander chamber); Percentage Loss of hydraulic conductivity (Xyl'em and Cavitron) and spatial distribution of embolism (x-ray microtomography)

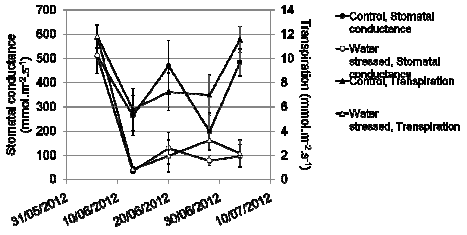
Controls Water stressed

Results

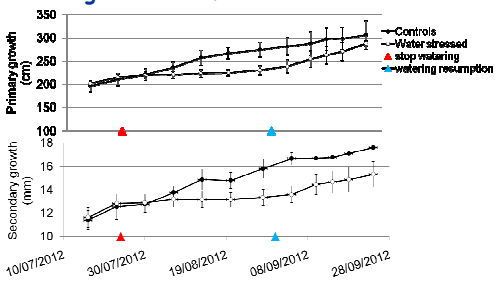
Xylem water potential



Stomatal conductance and Transpiration

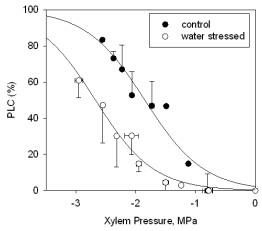


Height and Diameter Growth



In course of a water stress event, leaf water potential was lower in water stressed plants than in control plants. Poplars preserve their water content by limiting stomatal conductance and transpiration thus limiting the tension in xylem vessels and consequently the risk to break the water flux. As a consequence of stomatal closure, primary and secondary growth were reduced.

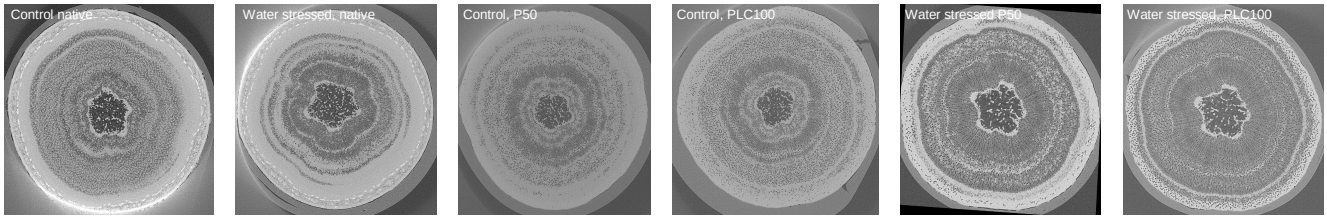
Vulnerability curve



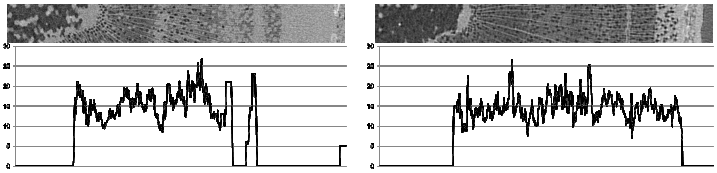
PLC: Percentage Loss of hydraulic Conductivity
P50: applied pressure inducing 50% of embolized xylem vessels

Vulnerability curves indicate that water stressed trees are less sensitive to embolism than control trees. The results suggest that poplar trees were able to acclimatize in response to a prolonged water stress by producing a higher resistant wood to embolism risk.

Vessel embolism observation by x-ray tomography



X-ray microtomography observations show the spatial distribution of embolized vessels. Number of embolized vessels is higher in water stressed trees than in control trees. However, at P50, control plants show 67% embolized vessels against 63% in water stress trees.



Conclusions and perspectives

During a moderate water stress, poplar trees show a decreased primary and secondary growth and produce an embolism resistant wood. Embolism sensitivity depends upon macroscopic parameters such as cell wall thickness and vessel density which are under investigatons.